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STATISTICAL DETERMINATION OF THE ACCURACY OF RECORDING OF A HIGH-SPEED ELECTROSTATIC RECORDER

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The accuracy of recording of rapidly changing processes with an electron beam electrostatic recorder, with high-speed mechanical scanning, depends on the precision of operation of all of its assemblies: linearity of the frequency and amplitude characteristics of the deflection amplifier, focusing quality and dynamic bias lighting as well as on the precision of feeding the data carrier. It should be noted that, at mechanical scanning speeds of up to 100-200 m/sec, which are necessary for recording data from a 0-50-100 kHz frequency spectrum, the accuracy of operation of the mechanical scanning assembly is a very complicated problem, especially if it is considered that the distance between the data carrier and the cathode ray tube line printing recorder should be held within the limits of 10-30 μm. The precision of feeding the data carrier is reduced, due to variability in its longitudinal speed and the appearance of transverse vibrations relative to the line writing tube, variability in the perpendicularity between the directions of the coordinates, and also due to change in the distance between the carrier and the line writer. This work is devoted to investigation of the data recording accuracy, as a function of all the factors enumerated, which cause vibrations of the data carrier and which affect the mechanical scanning precision. In particular, fluctuations in the linear velocity of the data carrier while recording cause a change in the time scale, according to the fluctuation pattern, i.e., a frequency modulation of the process recorded takes place. In the general case, the pattern of speed fluctuations, like other fluctuations of the carrier, are random processes. Therefore, the investigations were carried out by statistical methods.

Let a signal, with frequency f_{sign} be recorded and the speed of the carrier during recording be changed according to the pattern:

$$v_p(t) = v_{p_0}[1 + a_p \sigma_p(t)].$$

Then the execution period is

$$T_p(x) = \frac{v_p(t)}{f_{sign}} = v_p(t)\, T_{sign}$$

$$T_p(x) = T_{sign.}\, v_{p_0}[1 + a_p \sigma_p(t)].$$

i.e., modulation of the execution period takes place. Subsequently, the realizations are sampled and the function entered into the computer memory is frequency-modulated. Since the sampling is carried out at a considerably slower speed, it can be considered that the sampling intervals are constant and that the principal errors appear during recording. The distribution pattern of the recording function frequency, with a known distribution pattern of the scanning rate, is presented in the work. /267

Vibrations of the data carrier in the transverse direction cause a displacement of the zero line, i.e., in case of absence of the scanning beam on the screen of the recording tube, the signal recorded will coincide with the carrier vibration signal. Let $U_{sign}(t)$ be recorded, the carrier displacement be $\xi(t)$, and then the recorded data takes the form

$$u_p(t) = u_{sign}(t) + \xi(t).$$

A simple summation of the two signals takes place and, with a known distribution pattern of the data carrier vibrations in the transverse direction, the distribution pattern of the execution amplitude can be considered to be known also.

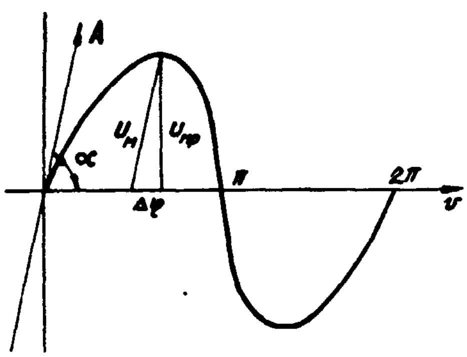

Fig. 1. Recording with perpendicular scanning coordinates $\alpha \neq 90°$.

Nonperpendicularity between the data carrier velocity vector and the line writing tube (Fig. 1) causes amplitude and time distortions. Let there be recorded a signal:

$$u_{sign}(t) = U_m \sin(\omega t + \varphi_0),$$ then

$$U_{mn} = U_m \sin x$$

$$\Delta\varphi = U_m \cos x \sin(\omega t + \varphi_0)$$

The execution function will have the form:

$$U_p(t) = U_m \sin x \sin[\omega t + U_m \cos x \sin(\omega t + \varphi_0) + \varphi_0].$$

In the case α = const, phase modulation takes place; in this case, the modulated and modulating frequencies coincide. /268

Variability in angle $\alpha \neq$ const causes a fluctuation in amplitude and phase, and the phase modulation index is variable, in this case. It was assumed in this work that the pattern of change in the angle between the coordinates is a random function, with a normal distribution pattern, the mathematical expectation of which is α_0 and dispersion σ. The frequency and amplitude distribution patterns were written down and the corresponding conclusions were drawn. The distribution pattern of the harmonic amplitude and harmonic coefficient, as a function of the angle between the coordinates, during recording of a harmonic signal, can be presented as an example (Fig. 2).

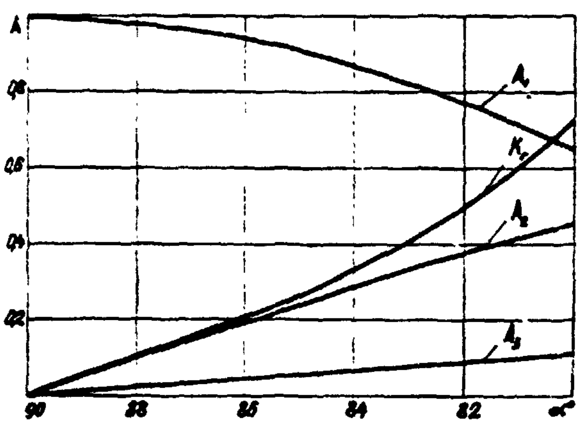

Fig. 2. Harmonic amplitude A_1 and distortion coefficient K_r vs. angle between scanning coordinates α.

The change in distance between the line writer tube and the data carrier causes a modulation in the brightness of the visual image. Since image brightness also changes, and as a consequence of change in the rate at which the process being investigated takes place, the use of brightness coordinates for transmission of analog data is undesirable, and additional modulation does not cause distortion of the data.

Extensive experimental data were presented in the work, a comparison of the accuracies of electrostatic and magnetic recording was made, and the results of the work are used for improving the recording accuracy and the quality of the visual image.

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